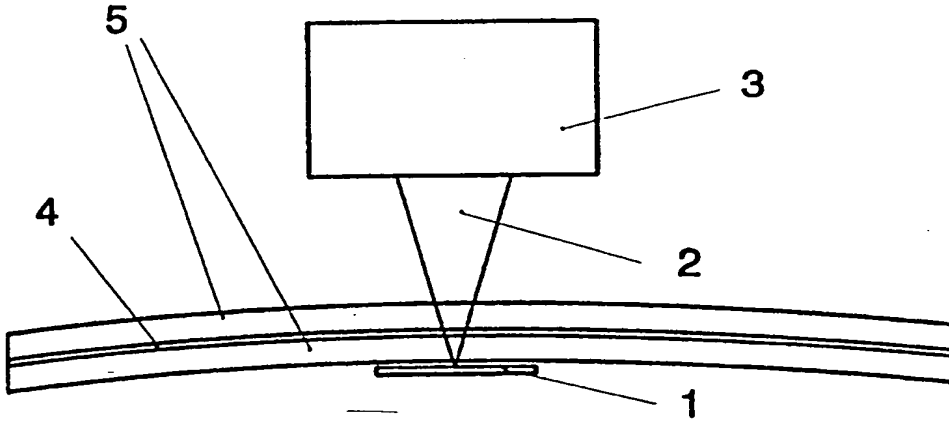


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<p>(21) International Application Number: PCT/FI95/00153 (22) International Filing Date: 23 March 1995 (23.03.95) (30) Priority Data: 941367 24 March 1994 (24.03.94) FI (71) Applicant (for all designated States except US): LASERPLUS OY [FI/FI]; Konepajankatu 16, FIN-11710 Riihimäki (FI). (72) Inventors; and (75) Inventors/Applicants (for US only): PAANANEN, Aku [FI/FI]; Huuhkajantie 7, FIN-13500 Hämeenlinna (FI). LIUKKONEN, Juha [FI/FI]; Keskustie 3 D 30a, FIN-15550 Nastola (FI). (74) Agent: BERGGREN OY AB; P.O. Box 16, FIN-00101 Helsinki (FI).</p>		<p>(81) Designated States: AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MN, MW, MX, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TT, UA, UG, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, MW, SD, SZ, UG).</p> <p>Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments. In English translation (filed in Finnish).</i></p>
<p>(54) Title: METHOD AND DEVICE FOR MAKING VISUALLY OBSERVABLE MARKINGS ONTO TRANSPARENT MATERIAL</p>		
		
<p>(57) Abstract</p> <p>The object of the invention is a method and a device for making visually distinguishable markings on the lower surface of a transparent material (5), using a vehicle (1). The marking is provided by causing a mixing of the transparent material and the vehicle by using a laser beam directed through the transparent material. The method can also be used to make markings on laminated glass without damaging the laminate.</p>		

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METHOD AND DEVICE FOR MAKING VISUALLY OBSERVABLE MARKINGS ONTO
TRANSPARENT MATERIAL

5 The object of this invention is a method and a device for making visually observable markings onto the surface of glass or other transparent material by using a laser beam. The term transparency implies that the material does not essentially absorb light energy on the wavelength of the laser beam
10 mentioned.

Markings are currently made by, e.g., sand blasting, silk screen printing, transfer marking methods, or the like. The main problem of the methods used has been a difficulty in
15 making individualized glass markings, e.g., serial numbers or changing bar codes in industrial production line applications.

The advantages of laser marking can be considered reliability, stability, convertability and flexibility. The applicability
20 of an Nd/Yag type laser for marking glass has generally been considered weak or nearly nonexistent because light is not absorbed by glass at this wavelength. The Nd/Yag type laser generally refers to a laser in which the laser beam is generated in an artificially grown crystal, i.e., in a laser
25 rod. The wavelength of the Nd/Yag laser is 1064 nm. This wavelength causes the effect of the beam passing through the glass.

Laser marking can be effected either by using a masking
30 technique in which the laser beam does not move and the desired figure is cut or etched on a cover plate, i.e., a mask, or by using oscillating mirrors.

The oscillating mirrors refer to refracting mirrors which are
35 a part of the beam deflection unit of the marking laser and which are moved to deflect the laser beam so that it follows the shapes of the desired marking pattern. The mirrors are controlled by servo motors or galvanometers with the aid of a

computer. By using the oscillating mirrors, fairly high speeds of movement of the beam, such as 1500 mm/s, can be achieved.

5 Laser marking is a frequently used method which has not been applied in glass marking previously, but transparent objects have generally been marked by using traditional means. These methods provide a fairly low marking cycle time. However, there are many production processes which require fast and individualized markings on transparent objects for subsequent
10 identification of the product. There are no laser marking applications for such processes. Furthermore, many marking methods require that the marking is made in a low-pressure chamber.

15 A laser beam directed through a transparent object and a metal vehicle placed in the vicinity of the surface to be marked has been used, according to EP patent EP 2738, to form coatings or conductive patterns, such as strip conductors, on the surfaces of isolating bodies. The patent deals with a slightly
20 different problem than the present invention as it does not endeavour to achieve a visual distinguishability of a pattern. Copper, brass, chrome, and aluminium are mentioned as vehicles. The patent also assumes that the transparent material is homogenous.

25 The object of the present invention is a method and a device for making individual and visually distinguished markings on transparent mediums quickly and advantageously in industrial production line applications. Another object is that the
30 method can be applied for marking laminated glass structures without damaging any parts of the structure.

The method according to the invention is characterized in that the laser beam is conducted through the medium to be marked
35 and focused on the vehicle on the opposite side, such as a colourant body, a metal sheet, or similar film so that a reaction is generated in the vehicle, comprising heating, melting and evaporation, and which causes the creation of a

pattern on the surface of the vehicle, a pattern which can be distinguished very well when examined visually. The method is further characterized in that the marking is essentially effected at normal pressure.

5

The invention is also related to a device for implementing the method. The device according to the invention is characterized in that means are provided on the opposite side of the medium to be marked, with respect to the laser beam, for bringing the vehicle, such as a colourant body, metal sheet or corresponding film to the vicinity of the surface to be marked, the equipment focusing the laser beam against the vehicle. The device is further characterized in that the part of the equipment where the marking is effected is essentially at normal pressure.

15

It is also possible to make markings by removing some of the vehicle from the surface of the glass. For instance, the black framing part of a windscreen serves as a vehicle and the laser beam is used to make the markings by removing the vehicle.

20

An essential difference of the present invention as compared with EP 2738 is a realization according to which the amount of the vehicle does not have to be so large that it would constitute an actual coating when making visual markings. In this case the consumption of vehicle is minimum and the whole procedure can be carried out considerably faster than the coating according to EP 2738. The method and device according to the invention has thus been optimized in the manner described below so that the pattern created on the surface of the material to be marked can be distinguished in the best possible way when examined visually, and that the laser beam does not damage the possible intermediate layers of the structure to be marked. There are essential differences in the performance characteristics of the methods. In EP 2738, the power of the laser beam is preferably 2 W and it is preferably moved at a speed of 2 mm/s. In the method according to the

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present invention the power of the laser beam is preferably 50 W and the speed of movement 250 mm/s.

5 Different embodiments of the invention are disclosed in the dependent claims.

The invention is described in the following in more detail with reference to an embodiment of the invention schematically illustrated in the appended drawing (individual marking of a
10 windscreen), the intention, however, is not to limit the invention to this embodiment.

The figure illustrates a diagram of the method according to the invention. Reference number 3 is used to mark a laser head, and laser beam 2 coming from the laser head is focused
15 on vehicle 1. Laser beam 2 travels through layers of glass 5 and a laminated layer 4. Vehicle 1 should be placed about 0.1 mm from the lower surface of the glass in order for the mixing of the vehicle and the glass to be effected in the best
20 possible way. The ambient conditions are normal air, pressure, and temperature. The forming of plasma in the vehicle and the adhesion of the marking on the glass surface can also be improved by surrounding the operating range by a gas atmosphere instead of air, such as argon which improves the
25 reaction.

When marking laminated glass structures such as windscreens, it is important that the marking does not damage the laminating layer between the glass layers. Due to the optical
30 characteristics of the laminating material, the laser beam is absorbed into it considerably better than into the glass. The power density of the laminate must be the lowest possible because otherwise the laminate bubbles and breaks the glass or at least weakens its strength. The power density of the
35 laminate is influenced by the power and the optical geometry of the laser beam, i.e., the original diameter of the laser beam and the focal distance of the optics used for focusing. The power density is highest near the focal point of the beam

which is situated on the surface of the vehicle, according to the method. The focal point, i.e., the focus, cannot be removed away from the laminate, i.e., below the surface of the vehicle because then the power density in the vehicle, correspondingly, is too low for making the marking.

Examples of the performance values, at which the power density of the laminate can be maintained sufficiently low, are provided below. The tests have been carried out by using the Power Line marking equipment of Rofin Sinar. The power of the equipment is 120 W and the galvohead type RSG 3.

Vehicle 1 must be a kind of mixture the factors of which influencing the markability include, e.g., the melting point, the boiling point, heat transmission, density, etc. On the basis of the tests, suitable vehicles include, e.g., the colouring agent used for silk screen printing dyeing of windscreen surfaces, brass, stainless steel, and zinc aluminium alloys. By further alloying the substances mentioned above by using, e.g., lead, tin, zinc, or the like, the markability can be influenced in a positive way. On the basis of the tests it has been noted that a mixture with a fairly high melting point provides good stability and a mixture with a fairly low melting point provides a good difference in contrast. The mechanical and chemical stabilities of the marking are important regarding the applicability of the method, so that it is not possible to later alter or remove the marking intentionally or unintentionally. The mechanical stability is preferably tested by rubbing the marking with different mediums. The chemical stability is tested by exposing the marking to corrosive and solvent substances.

The best marking result on a glass surface is achieved by using, as the vehicle, a silk screen printing colour which is used by windscreen manufacturers for dyeing the edges of windscreens. Examples are shown in the following for applying the method in different vehicles.

Example 1

Marking of a windscreen with a silk screen printing colourant as a vehicle.

Flux: PbO c. 45%, B₂O₃ c. 10%, ZrO₂ c. 5%, SiO₂ c. 35%,
5 Al₂O₃ c. 5%
Pigment: CuO 40%, Fe₂O₃ 10%, Cr₂O₃ 30%, CoO 20%
Focus: 166 mm
Frequency: 3200 Hz
Current: 14 A
10 Speed: 170 mm/s

The final result: The laminate does not bubble. The darkness of the marking is good. The marking is sharp. The mechanical and chemical stabilities are good. The limits of the performance values (speed and current) are defined by the fact
15 that the power density of the laser beam at the laminate may not be high enough to damage the laminate.

Example 2

Marking of a windscreen with stainless steel as the vehicle.

20 Focus: 166 mm
Frequency: 3200 Hz
Current: 14 A
Speed: 170 mm/s

Conclusion: The laminate does not bubble. The darkness of the
25 marking is reasonably good. The marking is sharp. The mechanical and chemical stabilities are good.

Example 3

30 Marking of a windscreen (light-coloured) with brass as the vehicle.

Focus: 165.5 mm
Frequency: 3000 Hz
Current: 14.75 A
Speed: 200 mm/s

35 Conclusion: The laminate does not bubble. The tone of the marking is good. The marking is sharp. The mechanical and chemical stabilities are good.

Example 4

Marking of a windscreen (dark) with brass as the vehicle.

Focus: 165.1 mm

Frequency: 3000 Hz

5 Current: 14.5 A

Speed: 200 mm/s

Conclusion: As in Example 3.

Example 5

10 Marking of a windscreen with lead as the vehicle.

Focus: 166 mm

Frequency: 1500 Hz

Current: 10 A

Speed: 170 mm/s

15 Conclusion: The laminate does not bubble. The darkness of the marking is better than with brass or stainless steel. The marking is not very sharp. The mechanical stability is good, the chemical stability is poor.

20 The examples mentioned above deal with the marking of wind-screens, in which the major problem is caused by the laminating layer between the layers of glass. When marking conventional glass, the focus, current or frequency values do not need to be limited because of the problematic behaviour of
25 the laminate, whereby the final result is even better with respect to its stability, darkness, and sharpness.

This invention can be applied to make markings on glass by using the Nd/Yag type of laser, with the aid of a vehicle,
30 through the glass on the lower surface thereof. Individualized markings of windscreens, for example, such as the production and inspection markings related to the manufacture, as well as the body numbers or license numbers of cars intended for the identification the cars, can be made through the layers of
35 glass and laminate on the lower surface (in the inside) of the windscreen and other glass. Using the present invention, individual markings are typically limited by one marking head (galvohead) in the area of less than 350 mm x 350 mm.

The usage possibilities of the method and device described above are not limited to the marking of windscreens, although this embodiment is used as an example to illustrate the application of the invention. The method and the device can be applied in all cases where individual markings should be done on transparent bodies in relatively small areas. In addition to the glass used in cars, trains, airplanes, and other means of transport, the special glass needed in the chemical industry and biotechniques are major areas of application. The above-mentioned matters are also true for individual pieces manufactured on production lines.

CLAIMS

1. A method for making markings on the surface of a material (5) by using a laser beam (2), characterized in that
 - a) the material to be marked does not essentially absorb the energy of the laser light on the wavelength of said laser beam,
 - b) the laser beam (2) is focused, through the material to be marked (4, 5), on the surface of the vehicle (1) on the opposite side thereof,
 - 10 c) the laser beam (2) causes a reaction in the vehicle, comprising the heating, melting and vaporization of the vehicle, and the atoms and molecules detached from the vehicle as a consequence of the reaction hit the material (5) surface to be marked and form a visually distinguishable mark on it,
 - 15 and
 - d) the marking according to the method is effected essentially at a normal pressure.
2. A method according to Claim 1, characterized in that said material to be marked comprises several sheet-like layers which are laminated into an integral structure.
3. A method according to Claim 2, characterized in that the power density of the laser beam on each layer (4, 5) of said laminated material is set lower than a power density that would damage the layer in question.
- 25 4. A method according to any of the preceding Claims, characterized in that said vehicle (1) is kept away from the surface (5) to be marked, during the marking, so that a gap of essentially 0.1 mm is provided between said surface and the vehicle.
- 30 5. A method according to any of the preceding Claims, characterized in that a gas atmosphere improving the reaction is arranged around the marking spot for the time of the marking.

6. A method according to Claim 5, characterized in that said gas atmosphere is essentially argon.
7. A method according to any of the preceding Claims, characterized in that the vehicle is a colourant for the silk screen dyeing of a glass surface.
8. A method according to Claim 7, characterized in that said colourant comprises a flux and a pigment, the flux comprising PbO c.45%, B₂O₃ c.10%, ZrO₂ c.5%, SiO₂ c.35%, and Al₂O₃ c.5%, and the pigment comprising CuO 40%, Fe₂O₃ 10%, Cr₂O₃ 30%, and CoO 20%.
9. A method according to any of Claims 1 to 6, characterized in that the vehicle is stainless steel.
10. A method according to any of Claims 1 to 6, characterized in that the vehicle is brass.
11. A method according to any of Claims 1 to 6, characterized in that the vehicle is lead.
12. A method according to any of the preceding Claims, characterized in that the marking head (3) follows the object (5) to be marked by deflecting the beam (2) during the marking.
13. A device for implementing the method according to any of the preceding Claims, comprising laser equipment (3) the laser beam (2) of which is used to make a visually distinguishable mark on the surface of the material (4, 5) which does not essentially absorb the energy of the laser light, characterized in that
- a) means are provided on the opposite side to the body to be marked to bring the vehicle (1), such as a colourant body, a metal sheet, or a corresponding film to the vicinity of the surface of the piece to be marked,

11

b) the laser equipment comprises optics focusing the laser beam through the piece to be marked on the surface of the vehicle, and

5 c) the part of the equipment where the marking is effected is essentially at normal pressure.

14. A device according to Claim 13, characterized in that the wavelength of the laser light of said laser equipment is 1064 nm or 532 nm.

10

15. A device according to Claim 13 or 14, characterized in that the moving speed of the marking head (3) is the same as the moving speed of the piece (4, 5) to be marked and that of the vehicle (1).

15

16. A device according to Claim 13 or 14, characterized in that the moving speed of the marking head (3) is lower or higher than the moving speed of the piece (4, 5) to be marked and that of the vehicle (1).

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17. A device according to any of Claims 13 to 16, characterized in that the power of the laser beam is essentially 50 W.

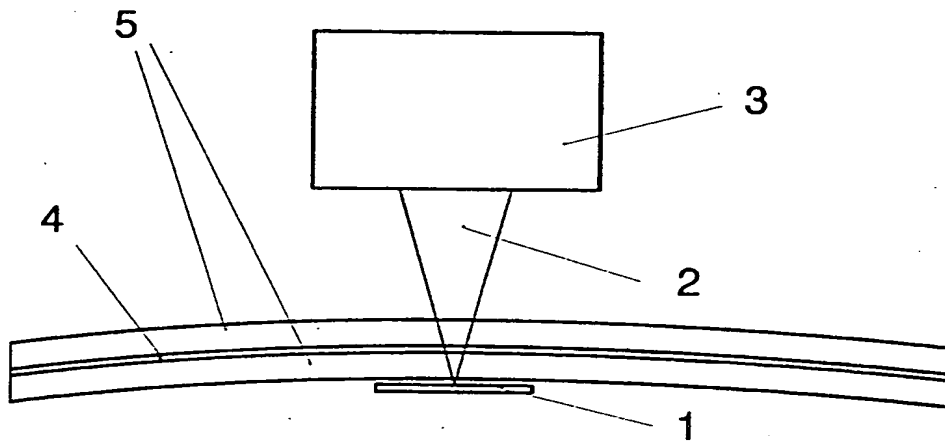
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18. A device according to any of Claims 13 to 17, characterized in that the moving speed of the laser beam is essentially 250 mm/s.

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19. A device according to any of Claims 13 to 18, characterized in comprising means for arranging a gas atmosphere improving the reaction around the spot to be marked for the time of the marking.

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FIGURE

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 95/00153

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: B41M 5/24 // C03C 23/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: B41M, B23K, C03C, C23C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0002738 A1 (INTERNATIONAL BUSINESS MACHINES CORPORATION), 11 July 1979 (11.07.79), page 3, line 29 - page 5, line 24	1,4,13
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Y	US 4737232 A (J. FLICSTEIN ET AL), 12 April 1988 (12.04.88), column 3, line 51 - line 52; column 6, line 24 - line 46	2,12
A	--	1,13
A	US 5173441 A (C. YU ET AL), 22 December 1992 (22.12.92), column 3, line 30 - column 4, line 48	1,13
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☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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Date of the actual completion of the international search

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Patent Abstracts of Japan, Vol 9, No 198, M-404, abstract of JP, A, 60-61193 (FUJI DENKI SOUGOU KENKYUSHO K.K.), 8 April 1985 (08.04.85) ---	1,13
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INTERNATIONAL SEARCH REPORT
Information on patent family members

10/07/95

International application No.
PCT/FI 95/00153

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